THE INSTITUTE OF PHYSICS

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The Bulletin is not intended for general publication : your copy should not therefore be passed to a library.

NOTICES TO MEMBERS

The Institute's House

During the summer the Board Room of the Institute's House has been redecorated and refurnished. A carpet and twenty-four armchairs upholstered in red leather to match the Presidential Chair provided by the South Wales Branch have been bought. It has been made possible by an anonymous gift of about £600 from a member, which the Board most gratefully acknowledges.

Bequests to the Institute

The Institute has benefited under the will of the late Mrs. Winifred Phillips whose husband, the late Major Phillips, was one of the founders of the Institute and was the Honorary Treasurer from 1925 to 1945. The bequest includes £2,500 for the Institute's general purposes, and the portrait of Major Philips by Sir William Nicholson which had previously been on loan and hangs in the Members' Room. In addition the Institute through its Benevolent Fund will have the right to nominate tenants for two flats when they become available, the upkeep of which will be provided by trust funds in the will. The funds concerned are also expected to provide sufficient income over that required for the upkeep of the property to contribute substantially to the Institute's Benevolent Fund. The Board is very grateful for this generous action. It is proposed to spend part of the £2,500 on one or two pieces of furniture for the House which could be suitably inscribed and will be a fitting expression of the interest which Major and Mrs. Phillips always showed in the Institute.

Science Abstracts

In order to maintain and improve the Abstracts service the Institution of Electrical Engineers (which produces and publishes Science Abstracts under the supervision of a Management Committee) has decided to increase the retail price of the annual volume from £2 10s. 0d. to £3 10s. 0d. There will be an increase in cost to The Institute of Physics and the Board of the Institute is discussing future arrangements with the Management Committee of Science Abstracts. In the meantime, the Board, wishing to assist members to continue to support this important publication, has decided that part of the increased cost shall be met from its own publications account, so that the charge to members in 1954 will have to be increased by only 7s. 6d. per volume, that is to £2 0s. 0d.

Protection from ionizing radiations

Attention is called to a new pamphlet entitled " Precautions in the use of ionizing radiations in industry " which has just been published for the Factory Department of the Ministry of Labour and National Service by Her Majesty's Stationery Office at 2s. net. It serves as a companion to two other official publications—the Recommendations of the British X-Ray and Radium Protection Committee and the Medical Research Council's Introductory Manual on the Control of Health Hazards from Radioactive Materials : dealing with precautions necessary in hospitals and in University and research laboratories ; it also deals with the properties of the various radiations emitted and their effects upon tissues and blood cells.

The Institution of Electrical Engineers Meeting

Members of the Institute are invited to attend a meeting of the Measurements Section of the Institution of Electrical Engineers to be held at the Institution on Tuesday, January 5, at 5.30 p.m. The papers to be read are " A Scaling Unit Employing Multi-Electrode Cold-Cathode Tubes " and " A Sensitive Pulse Trigger Circuit with a Stable Threshold " by K. Kandiah, and " The Development of a Neutron Spectrometer for the Intermediate Energies " by F. S. Goulding, J. C. Hammerton, M. G. Kelliher, A. W. Merrison, and E. R. Wiblin.

RESEARCH ASSOCIATIONS

IV — THE BRITISH COTTON INDUSTRY RESEARCH ASSOCIATION

By F. C. TOY, C.B.E., D.Sc., F.T.I., F.Inst.P.

The British Cotton Industry Research Association was founded thirty-four years ago and was one of the first of the new organisations having their origin in discussions that took place during the first world war. It was founded, as the name implies, to serve the British Cotton Industry in the days when this defined an industry whose raw material was cotton. To-day this is only partly true ; large quantities of synthetic fibres are now also used, and the interests of our physicists include all fibres processed on cotton-type machinery.

It is fashionable in some quarters to decry the cotton industry, saying that it is too old fashioned and conservative in adopting new ideas. There is no evidence for this in the history of the growth of the Research Association, from small beginnings in 1920 to a staff approaching 500 with an expenditure of over £300,000 in the current year ; and now the voluntary acceptance by the whole of the industry of a statutory levy for research. Few organisations outside the Government Service can offer greater security to their staff, and none anywhere a happier blend of academic atmosphere with an intense interest in industrial application.

In his most interesting account of the work of the Electrical Research Association, Dr. Whitehead mentioned that the research work carried out by his organisation represented only a very small proportion of the total research undertaken in the electrical industry. In the old traditional industries like ours, not based on modern scientific discoveries, this was certainly not so, and even to-day, in spite of the great increase of research within the cotton industry, the Research Association's proportion of the whole is still quite considerable. Another feature of our industry, which differentiates it from some of the modern ones is the basic similarity of the manufacturing processes in hundreds of mills. These are circumstances that make the Research Association the ideal place to investigate the fundamental science of all the processes used and to develop new ideas having wide application in large sections of the industry. In carrying out these functions the physicist plays an extremely important part.

Since the purpose of the Shirley Institute is to serve the industry, it might be thought the physics done at the Institute must all be applied. This is by no means so. Much of our work does, of course, arise directly from technical needs but quite frequently we feel the need for general physical information in some field and thus there arise items of pure research that should satisfy the most academic mind. At any rate, such work is far enough removed from special technical application to have wide physical interest, as the following examples will show.

The phenomenon of static electricity is important in textile processing but existing general knowledge on the subject does not carry us very far, and so we are engaged on fundamental studies on the generation of static charges, on the movement of ions and other particles towards electrostatically charged materials, and on the performance of radioactive "static eliminators." Preliminary results of the first were reported to the Institute of Physics Conference held in London in March, 1953.

The friction between textile materials, and between textiles and other materials, is very important practically and is the subject of intensive study. Here it is not a case of doing pioneer fundamental work on friction in general, but of using the observations made by Bowden and others, and the resulting theories, to guide the investigation of the friction of textile materials and explain the results. The technical background sets the field for this work but does not circumscribe it, and it is expected that as it develops the work will shed light on the phenomenon of friction in general.

Examination of the basic materials used in textile manufacture forms an important part of the work, and perhaps the most fundamental task is to determine their structure from the molecular scale upwards. It is characteristic of all the artificial fibres, and most, if not all, of the natural fibres, that they are composed of long chain molecules with few covalent side links but many polar groups which may lead to less permanent attachments between chains. There is usually some degree of preferred orientation, which may be longitudinal as in stretch-spun artificial fibres, or spiral as in cotton. Where the orientation is considerable, there is a tendency for the chain molecules to "click" together to form a crystalline region which may have physical and chemical properties distinct from those of the less orderly regions. X-ray diffraction and, to a less extent, the birefringence of fibres have been much used at the Shirley Institute to investigate these matters. Structural features which are coarser but still beyond the optical microscope have been examined by means of the electron microscope, usually in material broken up by mechanical means, or from casts taken of the fibre surface.

Academically interesting as the structure may be for its own sake, at the Shirley Institute we are mainly concerned because of its effect upon mechanical and other properties of the material. The following are some properties particularly

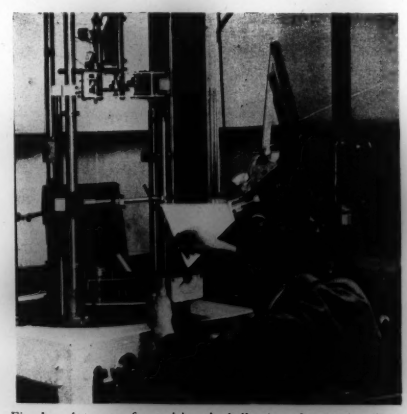

Fig. 1. *Apparatus for studying the ballooning of a rotating thread such as occurs in ring spinning. The observer is measuring the angle subtended at the apex of the balloon. There is also equipment for measuring the tension in the thread and for taking flash photographs of the balloon in two planes.*

sensitive to structural changes : strength, elasticity, uptake of moisture, dyes, etc., swelling and moisture diffusion. These all vary according as the molecular chains are crystalline or irregular, coiled or straight, long or short, free or cross-linked. The first two alternatives are examined, as we have seen, by X-ray and optical methods, and the third by measuring various properties of solutions, such as viscosity, osmosis, and sedimentation in the ultra-centrifuge ; whilst the fourth has been investigated at the Institute indirectly from the X-ray data and from studying such effects as that of temperature on properties associated with plasticity. The method of infra-red spectroscopy, though not yet employed at the Institute, seems promising for the examination of cross-linkages. The binding of dyes to substrate is examined by comparing the absorption spectra of dyed films with that of the dyes dispersed in various solvents. Those amongst textile materials having fewer cross-links often show the rubbery type of elasticity above a certain temperature, in which the tension arises from the motions of the molecules rather than from inter-molecular forces, and is thus analogous to the pressure of a gas.

Some textile materials, especially the natural fibres, may absorb 10, 20, or even 30 per cent of moisture without appearing to contain any liquid water. The study of this absorption is important to the industry, not only for its own sake (some forms of textile goods are sold by weight !) but more especially because the mechanical and electrical properties of fibres are greatly affected by their moisture content, with consequential effects upon the processing. The absorption of moisture by textile materials shows interesting phenomena such as hysteresis and time lag, and whilst much information is available for large cycles between dryness and saturation, there are practically no published data dealing with the possibly more important case of small cycles in relative humidity. The *rate* of uptake of moisture by textiles is also important, and theoretical and practical studies have shown that this is intimately connected with the passage of heat into or out of the package—sometimes the controlling factor. The two diffusion processes (i.e. those of heat and moisture) are coupled in a way mathematically very similar to that of coupled vibrations, resulting in a pair of " normal modes " of diffusion, each concerned with both diffusants.

The applied research done at the Shirley Institute also has interest for the physicist since we do all such research as fundamentally as we can. The antithesis of " applied " is " pure " and the antithesis of " fundamental " is " superficial " or, in this context, " empirical." For obtaining immediate results of limited application, as when determining the best settings, speeds, temperatures, and so on, for a particular type of machine or process we make empirical experiments, varying the factors systematically and observing the results. But we find that this sort of " research," useful and necessary though it is, does not advance knowledge far, and it is much more rewarding to analyse the functioning of the machine or process into its physical elements and study them fundamentally.

For example, in the preparatory process of cotton spinning, cotton from the bale is transported pneumatically and is separated from sand, seed-coat, and other " trash " by the action of gravity, centrifugal forces that come into operation as the mixture of fibre and trash in the air stream follows a curved path, and the different buoyancy of cotton and trash ; and the whole is affected by the extent to which the compressed cotton from the bale is " opened " during processing. This complex of phenomena has been studied to such good effect that a new machine has been devised that removes two or three times as much trash as any machine of conventional type.

Cotton yarns and the intermediate products are not uniform in thickness along their length, as, ideally, they should be, but vary according to a very complicated quasi-periodic pattern. This variation is important because it reduces yarn strength and detracts from the appearance of the yarn, the effect on appearance depending on the form in which the yarn is used—whether as warp or weft in the cloth, and, if as weft, on the relation between the cloth width and the wave-length of the variation. A quantitative study of the effects of yarn variation constitutes a field in which much has been done. The physical causes of the variation are complex and are also being actively investigated. They arise from the nature of " drafting "—the process of attenuating the product stage by stage from the early " sliver " of rope-like thickness to the final yarn. This is done by series of pairs of rollers, arranged like the rollers of the domestic mangle, through which the material is fed and which control its rate of passage. The front rollers move faster than the back rollers in a sequence so that the issuing material is thinner than that fed. Variation arises from several groups of causes.

(i) The distance between the nips of any two adjacent pairs of rollers must not be much less than the lengths of the longest fibres or the fibres will be broken. But if the fibres of any one mixing vary in length so that the shorter ones " float " between the two roller-nips, they are for some time out of the control of both pairs of rollers and are carried by the longer fibres. Floating fibres move irregularly and tend to produce the wave-like variation known as the " drafting wave." So far experimental physics and mathematical analysis have led to some understanding of the laws of motion of the floating fibres, but very much remains to be done.

(ii) At some stages of drafting the rollers may not grip the fibres sufficiently to prevent them from slipping through. Roller-slip, when it occurs, gives rise to a periodic variation of thickness, the wave-length of which can be calculated.

(iii) Mechanical imperfections in the drafting rollers such as eccentricity or variations in hardness give rise to accurately periodic variations in yarn thickness.

(iv) The rollers may rotate, not steadily, but with a high frequency vibration superimposed on the steady rotation and this, when it occurs, produces a periodic variation in the product. Roller variation can be generated by imperfections in the driving gears and stick-slip friction in the bearings and its frequency as well as its occurrence is affected by the torsional and other elasticities in the system. Research is now in progress to measure the importance of these factors in various circumstances, to measure the frequency of vibration that can be tolerated from the point of view of the product, and to provide practicable remedies.

When it is realised that in a yarn, any or all of the four types of variation may be present and that yarn is the product of several processes at all of which variations of different wave-lengths can be introduced, it will be seen that nothing less than a fundamental study of yarn variation can untangle the skein of causes and effects and offer any hope of a solution to the problems being reached.

Fabrics in the unfinished state may show unwanted irregularities in appearance that may be due to yarn variation, to variations in the spacing of the threads arising from imperfections in gears and to variations in yarn tensions from thread to thread and along the thread, such variations sometimes

Fig. 2. An apparatus for the controlled soiling of fabrics. Air laden with a known quantity of carbon black is driven round the trunking at a specific speed, and the fabric under test is exposed at a definite angle to the air stream for a definite time. The degree of soiling of the fabric is measured both optically and gravimetrically.

having been introduced in a winding process preparatory to weaving. As a result of researches of past years such irregularities can now be diagnosed and remedies proposed.

Physics also enters into the testing and characterisation of the raw materials and products of the cotton industry. The appraisal of raw cotton has traditionally been a subjective process by a skilled and experienced grader, but progress has been made with developing physical tests which at first supplement the subjective tests—whether the physical will ultimately supplant the subjective remains to be seen. In developing tests, the physical qualities have to be separated : length, fineness, "maturity," strength, inter-fibre friction, and so on ; and practicable testing methods have to be devised. At first the testing methods have been precise, but suitable more for laboratory work and research than for the hurly-burly of mill life, where a result is useful only if it can be obtained quickly—that it may be crude does not much matter. Indirect but quick methods of measuring cotton fibres are now being developed, involving measuring the optical density of tufts of fibres photoelectrically, the diffraction of light through tufts, and the air porosity of plugs of fibres ; and, as seems to be the case in other fields, the instruments developed for these new methods are more complicated and expensive than those required for the old. The results of the indirect methods have, of course, to be interpreted in terms of the more fundamental physical quantities ; and it is a more long-term research to interpret the results of the physical measurements in general terms of the performance of the fibre in processing and use.

Fabrics are submitted to an enormous number of uses ; each use usually involves several physical phenomena and correspondingly several physical properties are important. In wear, for example, a fabric may deteriorate through a wearing away of the fibre, through fibres becoming teazed out of the fabric, through a weakening of the fibres by repeated flexing, through chemical tendering from weathering, or through a mixture of these ; and the relative importance of the types of deterioration depends on the conditions of use. In some uses the suitability of a fabric depends largely on its reaction to complex stresses in three dimensions. Fabrics for clothing are required to provide protection against wind, heat (or cold), water, dirt particles, or two or more of these, and usually they are required to have some degree of permeability to air and vapour. The soiling of fabrics occurs through contact with the soiling matter, the deposit of air- and water- borne particles, the electrostatic attraction of particles, and a difference in temperature between the fabric and the ambient soil-laden air ; and in some uses there is probably a dynamic equilibrium between soil deposited and lost by the fabric. Research work at the Shirley Institute is directed towards analysing qualitatively the physical elements of various types of use ; devising methods and instruments for measuring the basic physical properties involved ; investigating how such factors as the fabric structure, the fibres and yarns used, and the "finish" applied to the fabric, affect these properties ; and correlating the results of the physical measurements with performance in use. In this field a wide range of physical techniques of the more classical sort is used.

A topic of wide scope is the replacement of subjective judgments of qualities of fabrics by the relevant definable physical quantities. Examples are colour, lustre, and various aspects of "handle," such as "cold feel," "roughness," "softness," "fullness," "gloviness," "paperiness," and "draping quality." In such cases the first step is to guess what physical quantity or combination of quantities is most relevant. A large number of samples are then measured instrumentally and offered to as many experienced judges as possible for ranking in order of the subjective quality. If the

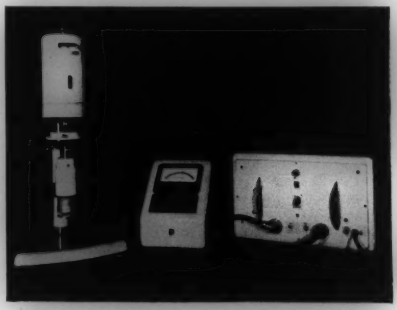

Fig. 3. The Ferranti-Shirley Viscometer for measuring the viscosity of starch and other viscous pastes.

rankings are reasonably consistent amongst themselves (by no means always the case !), and if they agree closely with the order in which the physical measurements place the samples, the instrumental quantity may provisionally be given the same name as the subjective quality. Readers will be aware that a process of this sort has been thoroughly carried through to a first approximation in the case of colour, where the physical measurement of the colour of a reflecting surface is the variation of reflectance with wave length. The "lustre" of fabrics has been investigated at the Shirley Institute, and here the measurement is that of the variation of reflectance with the angles of illumination and viewing. The difference in character between the "lustre" of a fabric and the "gloss" of a smooth paper is due to the fact that in the former case there are special directions in the surface (those of the fibres in the threads), with the result that the reflectance varies as

Fig. 4. A shuttle projected between two sheets of warp threads. The photograph, taken with an exposure of 4 micro-seconds, shows the peculiar appearance of the trailing weft.

the fabric is rotated in its own plane. Lustre, like colour, requires more than one variable to describe the stimulus. " Cold feel," on the other hand, can probably be described with a single variable, but this is determined by a complicated combination of thermal conductivity, specific heat, smoothness of surface, and the number and rigidity of the fibres which tend to hold the skin away from the surface. " Draping quality " is more completely understood, and is determined by the stiffness and weight per unit area of the fabric, and, to a less extent, by its ability to become sheared in its own plane (" sleeziness "). Instruments have been designed to measure all these properties, and much use is made of the mathematical theory of the bending of beams.

Some of our instruments have to be developed into a form suitable for routine mill use. Yarn tensions, for example, have to be measured in almost all processes. These may be relatively steady or slowly changing, or they may have superimposed a rapid fluctuation which in different circumstances may require to be damped out or measured. Sometimes the element that detects the tension must be fitted into a small space, and the movement of the spring or whatever it may be must be so small that it does not appreciably affect the yarn path and hence the tension that is being measured ; sometimes these conditions are not exacting. Both simple optical systems and modern electronic devices are used for magnifying movements and " signals " and for producing readings and records. Another problem not unlike that of the measurement of tension is the measurement of the distribution of pressure across the nip between pairs of calender bowls (or rollers). There is considerable need in textile research for the application of the classical physics of the measurement of forces, both dynamic and static, in complicated elastic systems.

Rheology has important textile applications. The entire craft of calico-printing is based upon the particular viscosities exhibited by non-Newtonian colour pastes at certain shearing stresses, notably the low stress involved in the furnishing of colour to the engraved roller, of the order of 100 dynes per square centimetre, and the much higher stress (about 4,500 dynes per sq. cm.) of the actual printing operation. Subjective judgment of appropriate viscosity is one of the traditional skills of the printer. Physicists at the Shirley Institute, however, have devised a novel form of viscometer, developed in collaboration with Ferranti, Ltd., in which the liquid under examination is sheared between a rotating cone and a plate ; it is capable of rapid measurement of the viscosity of a printing paste over a wide range of shearing stresses. With this instrument the suitability of a printing paste for a particular duty can be quickly and reliably assessed.

To engineers and physicists seeing it for the first time the loom is a weird and wonderful machine ; I remember a distinguished physicist looking at a loom working at the Shirley Institute and saying under his breath, and in a ruminative way, " It is not true ; it cannot be." Perhaps the most unbelievable part of the loom is the shuttle and its associated mechanism. The shuttle is accelerated from rest to a speed of about 40 feet per second over a distance of about 6 inches, projected across the loom, and brought to rest from almost full speed over a distance of about 4 inches ; the maximum acceleration may be 60–80 g and the maximum retardation 200–300 g. This is done about three times a second. Instruments are required and have been developed for measuring the time-displacement curve of the shuttle, especially during the acceleration and retardation, for measuring the shuttle speed at any point and maximum acceleration and retardation (these instruments have been designed for use by technicians in mills), and for measuring the strain in the mechanism on a time base. The whole research and the application of the results are a good example of the usefulness, even in the atomic age, of classical mechanics.

Physicists are valued not only for their skill in applying physical techniques but also for the scientific approach to problems that a good training in physics inculcates. Many of our technical problems are complicated, as I have illustrated, and there is plenty of scope for the exercise of scientific ability in analysing them and devising fruitful methods of attack. Moreover, some of our work leads to the development of machinery, and here the physicist's approach, regarding mechanical difficulties as scientific problems to be investigated quantitatively, proves to be most effective.

Naturally, no physicist at the Shirley Institute covers the whole field. Each at one time is directly concerned with one problem or with a limited range of problems, and exercises only a portion of his knowledge as a physicist, although we encourage everyone to know about and take some interest

in all the work. Each physicist has his periods of high interest, in pursuing theoretical analysis as well as in developing apparatus, and occasionally there are moments of excitement when some new effect is discovered or some new relationship reveals itself that makes sense of hitherto discordant results. At the end of every research there comes what some experimenters seem to find the dullest and most difficult task of all—the writing of a report or paper !

What sources of interest are there, for the physicist, other than those mentioned ? The short answer is : in the industry itself. There is interest not only in developing apparatus for taking measurements, but also in knowing what measurements to take and in interpreting the results. This interest can only be excited by taking an interest in the technology of the industry, and generally speaking, the physicist at the Shirley Institute will be happiest and most successful when he concerns himself with the technical problems of the industries served. He must be more than a physicist—he must be a technologist in the highest sense. And it is in working out the application of physics to the industrial problems, by formulating a problem, devising lines of attack, and utilising experimental results that the physicist will show his quality as a scientist.

REVIEWS OF BOOKS

Photograms of the year 1954. (London : Iliffe and Sons Ltd.). Pp. 36 + 96 plates. Price 12s. 6d.

This, the fifty-ninth, issue of the well-known illustrated review of the principal exhibitions of pictorial photography contains ninety-six excellent reproductions with comments on each of them by Mr. R. H. Mason. These comments are by no means the least valuable feature of the book for they provide the keen amateur pictorialist with most helpful indications—in language not above his head—of the points which make for excellence. There is an interesting selection of sixteen reproductions of early work chosen from the permanent collection of the Royal Photographic Society.

At such a modest price this publication is unusual value for these days.

The Works of Archimedes. Edited by T. L. Heath. Pp. cxli + 377. (New York : Dover Publications). Price $1.95.

This is one of a new series of paper-bound books published by Dover Publications. It combines in one volume the 1897 unabridged Heath edition of " The Works of Archimedes " with " The Method of Archimedes " discovered by Heiberg in 1906. The latter is specially interesting as it gives us an insight into how " the great geometer " worked and in particular how he investigated certain mathematical problems by using ideas taken from mechanics. He applied, for instance, the theorem of moments in mechanics to establish a fundamental result in the geometry of the parabola ; a stricter mathematical proof followed. As Heath writes " here we have a sort of lifting of the veil, a glimpse of the interior of Archimedes' workshop as it were." Archimedes tells us " for certain things first became clear to me by a mechanical method . . . it is of course easier, when we have previously acquired, by the method, some knowledge of the questions, to supply the proof than it is to find it without any previous knowledge." One should not be surprised at the antiquity of this truth, especially when it is enunciated by one who was not only a master of geometry but a genius in contriving mechanical devices. It has been verified, of course, by numberless investigators subsequently.

The " Works," to which Heath wrote a long and valuable introduction, include theorems on the sphere and cylinder, on conoids and spheroids, on spirals, on the centres of gravity of plane figures and on the equilibrium of floating bodies. Everyone knows the story of Archimedes and his bath, and many appreciate that the whole science of hydrostatics is due to him, but few realize that he went so far as to investigate completely the positions of rest and stability of a right segment of a paraboloid of revolution floating in a fluid. There is a fascinating section on the measurement of the circle which reproduces his proof that π lies between $3\frac{1}{7}$ and $3\frac{10}{71}$, whilst the article entitled the Sand Reckoner, in which Archimedes estimates the number of grains of sand that would fill the " Universe " is reminiscent of a similar estimate in modern times by Eddington.

While welcoming the appearance of this cheap edition, one wonders whether it is right to call it " a student's book." A certain mellowness of learning has to be achieved before a historical work of this kind can be appreciated. It is this that bedevils the teaching of the history of many branches of science.

J. Topping.

Principles of Electronics. By H. Buckingham and E. M. Price. (London : Cleaver-Hume Press Ltd.) Pp. 335. Price 15s.

To produce an attractively printed and illustrated book of moderate price dealing with electronics for engineering students is praiseworthy, but the authors would need a special dispensation from heaven to deal satisfactorily with the wide range they have attempted. Using little mathematics, there are accounts of atoms, electrons, radiation, electricity in gases, emission phenomena, vacuum tubes, circuits, engineering applications, measurements, iconoscopes, orthicons, cyclotrons, betatrons, electron microscopes and even a Geiger counter with, strangely, $10^{10}\,\Omega$ in its circuit. Many of these topics receive only a page or half a page of description. It would have been better to have left some of them out altogether.

Too often statements in the book would not be understood by a reader without previous knowledge. What, for example, is he to make of the discussion of energy levels in solids based on a one-line over-simplified statement of the exclusion principle ? The text is best when considering circuits, but even then only brief outlines are possible and many fundamental points which are essential to a proper understanding are left undiscussed.

The book should be useful to a science or engineering student who wants to get an outline idea of electronics and its manifold applications. However, it is difficult to recommend it for technical college courses because, on too many occasions, the information is skimpy and demands a more logical approach with more consideration of fundamentals than is to be found here.

J. Yarwood.

REPORT ON A SURVEY OF SALARIES AND EMOLUMENTS PAID TO FELLOWS, ASSOCIATES AND GRADUATES OF THE INSTITUTE OF PHYSICS, 1953

Approved and adopted by the Board of the Institute on November 17, 1953

Preamble

Surveys of salaries and other emoluments paid to members of certain grades of The Institute of Physics were conducted in 1948 and 1951. A third survey relating to salaries on July 1, 1953, has been made and the results are presented in this report. For ease of comparison the results are given in the same general form as those of 1951. The nature of the emoluments considered is explained below. On the whole they consist of salaries and, for a minority, of additional fees. No account is taken of such emoluments as employers' contributions to superannuation.

The data here presented are not, and are not intended to be, a simple guide to salaries which may be appropriate to all graduates in physics. They are a factual record of the salaries paid to a high proportion of members of three grades of the Institute and provide information on the degree of variation within and between the grades.

The principal difference in the requirements for membership of the three grades from which information has been obtained is in the length and quality of the professional experience demanded. For Fellowship and Associateship a high academic standard is required, normally the holding of a good honours degree in physics. For Fellowship the regulations state that "a very high level of scientific attainment or responsibility" is essential. The minimum period of approved experience is seven years in original research or ten years in other responsible work in physics. The minimum age for Fellowship is thirty years but most successful candidates are several years above that age at the time of election. For Associateship (minimum age 25 years), a minimum period of three or five years, according to the class of degree held, is required and this experience is carefully investigated; evidence of some originality, of initiative and some degree of responsibility must be provided. For Graduateship (minimum age 21 years), candidates are required to have a degree in physics and to be engaged in appropriate work but no minimum length of experience is prescribed.

All members of the Institute are required to comply with high standards of professional behaviour.

Data Received

All Fellows, Associates and Graduates living in Great Britain were invited to supply information relating to their salaries and emoluments at July 1, 1953. The response has been even better than that of the two previous surveys. The signing of the cards was optional but only 45 cards (2½%) were returned unsigned. The Board of the Institute records its thanks to all who have provided data, including those whose cards have been excluded from the analysis for reasons given below.

Table 1. *Cards sent and returned*

Grade	*Sent*	*Returned*	*Percentage returned*	*Percentage returned in 1951*
Fellow	660	456	69	61
Associate	1315	1021	78	70
Graduate	609	470	77	73
	2584	1947	75	68

Table 2 shows the distribution of the returns among age and occupation groups.

Classification and Exclusion

Members indicated on the cards the nature of the organizations in which they were employed but, as in previous surveys, some ambiguity has arisen. As before, members on the staffs of teaching hospitals have been included with university staffs where the member himself has pointed out the ambiguity by marking his card as both "university" and "hospital." Members employed by firms in the steel industry are included in the "industry" group and not with "nationalized industry."

Table 2. *Classification of returns by ages and occupations*

Age group	*Under 31*				*31–41*				*41–51*				*over 51*				*Total*			
Cards included *Occupation*	*F.*	*A.*	*G.*	*T.*	*F.*	*A.*	*G.*	*T.*	*F.*	*A.*	*G.*	*T.*	*F.*	*A.*	*G.*	*T.*	*F.*	*A.*	*G.*	*Total*
Industry	—	120	220	340	35	163	15	213	59	39	—	98	29	9	—	38	123	331	235	679
Nationalized Industry	—	10	10	20	6	18	—	24	5	—	—	5	1	—	—	1	12	28	10	50
University	—	58	8	66	25	57	1	83	45	6	—	51	38	1	—	39	108	122	9	239
Scientific Civil Service	—	55	48	103	18	103	8	129	25	20	—	45	21	5	—	26	64	183	56	303
Other Government Posts	—	8	7	15	1	19	1	21	5	6	—	11	5	2	—	7	11	35	8	54
Research Association	—	26	26	52	12	31	4	47	15	6	—	21	8	—	—	8	35	63	30	128
Technical Colleges	—	22	16	38	10	32	7	49	16	35	1	52	11	13	—	24	37	102	24	163
Schools	—	5	11	16	1	27	6	34	3	31	3	37	2	11	1	14	6	74	21	101
Hospitals	—	13	6	19	4	20	—	24	4	—	—	4	—	—	—	—	8	33	6	47
Other Scientific Posts	—	—	3	3	3	8	—	11	7	4	—	11	2	1	—	3	12	13	3	28
	—	317	355	672	115	478	42	635	184	147	4	335	117	42	1	160	416	984	402	1802
Cards excluded																				
Retired																	27	8	—	35
Research grants, etc.																	—	6	54	60
Other reasons																	13	23	14	50
Total cards returned																	456	1021	470	1947

Cards from retired members have been excluded. Returns from younger members, mainly Graduates, in receipt of D.S.I.R. or other grants for full time research for higher degrees, have also been excluded. Among other cards excluded were returns from members of the armed forces, whether regular or national service, overseas members temporarily in this country but paid relatively high salaries through the inclusion of a substantial expatriation allowance, and several younger members in process of taking up posts in America.

As far as possible, the decision as to which emoluments other than salary should be included in the analysis has been taken in the same way as in 1951. For members in industrial and similar posts the question rarely arises but only basic salary and any bonus on profits have been taken into consideration. Sums earned by a few younger men by evening class teaching have been disregarded. For members in university posts such additional earnings as fees for consulting and examining and income from royalties, etc., have been included as they are considered normal to such posts and, among the older men are commonly substantial. A few returns were made of £1,000 or more for such extra work but few of the younger university men earn more than trivial amounts in this way. Returns from technical college staffs have been treated similarly ; for these members the sums involved are generally very small.

For schoolmasters, no earnings other than salary and special responsibility allowances have been included for Associates and Graduates. With the six returns from Fellows who are schoolmasters, only such extra earnings as book royalties have been included.

Salaries of Fellows

Information about Fellows' earnings is again presented with only broad classification as there is little evidence of correlation of salary with age. The data are given in Table 3. The group " Government " includes the scientific civil service and other government posts ; " Industry " does not include nationalized industries, returns from which are included in " other " for consistency with the procedure of 1951.

Table 3. *Emoluments of Fellows*

	Age under 41						*Age over 41*						
Occupational group	*Less than £1,000*	*£1,000–£1,499*	*£1,500–£1,999*	*£2,000–£2499*	*£2,500 and over*	*Total*	*Less than £1,000*	*£1,000–£1,499*	*£1,500–£1,999*	*£2,000–£2,499*	*£2,500–£2,999*	*£3000 and over*	*Total*
Industry	1	18	7	7	2*	35	4	21	31	16	7	9	88
University	2	14	4	4	1	25	1	33	22	18	8	1	83
Government	2	13	3	1	—	19	—	24	25	6	1	—	56
Research Associations	2	6	4	—	—	12	1	7	10	3	1	1	23
Technical Colleges	2	8	—	—	—	10	1	13	9	4	—	—	27
Schools	—	1	—	—	—	1	1	3	1	—	—	—	5
Other	—	7	6	—	—	13	1	5	5	4	2	2	19
	9	67	24	12	3	115	9	106	103	51	19	13	301

* *Includes one return over £3,000*

Comparison with previous surveys

The returns indicate a significant increase since 1951 in the average earnings of Fellows. In 1951 the median salary of Fellows of all ages and occupations was about £1,400 and the table of the 1951 report corresponding to Table 3 above was, for that reason, given with £1,400 as the division of the grouping of salaries £1,000–£1,999. For the purpose of comparison, the data of the present survey is summarized (as percentages) in similar groupings in Table 4 which also gives the corresponding 1951 percentages.

Table 4. *Fellows : Comparison of* 1951 *and* 1953 *returns*

(*Note : The data are given as* **percentages** *of each group*)

		Under £1,000	*£1,000–£1,399*	*£1,400–£1,999*	*£2,000 and over*	*(Number of returns)*
Age under 41	1953	8	50	29	12	(115)
Age under 41	1951	31	39	22	7	(140)
Age over 41	1953	3	29	41	28	(301)
Age over 41	1951	12	31	36	20	(261)
All ages	1953	4	34	38	24	(416)
All ages	1951	19	34	31	16	(401)

Approximate median salaries for Fellows now are £1,350 up to 40 years and £1,600 above that age, with £1,550 as the approximate median for all ages.

The comparisons made in 1951 with the results of the 1948 survey can be extended and this information is given in Table 5.

Table 5. *Fellows—comparisons of 1948, 1951 and 1953 returns*

(a) *Percentage of Fellows (all groups) earning over £1,200 and over £1,500.*

	Under 41			*Over 41*		
	1948	1951	1953	1948	1951	1953
Percentage earning £1,200 or over	15	43	65	48	67	87
Percentage earning £1,500 or over	6	23	34	29	45	62

(b) *Percentage of Fellows over 41 years earning over £1,500 and over £2,000 in main occupational groups.*

	Percentage over £1,500			*Percentage over £2,000*		
	1948	1951	1953	1948	1951	1953
Industry	40	52	72	28	25	36
Universities	42	55	59	12	28	32
Government	13	53	57	4	7	12

Table 6 gives information on average salaries in the main groups. In order to avoid undue weight to the highest returns, the data for returns under £2,000 are shown separately.

Because of the relatively small numbers involved, averages are given to the nearest £50. The number of returns in each group is given in brackets.

Table 6. *Fellows—Average Salaries*

	Fellows earning under £2,000				*Fellows earning £2,000 or more*			
	Under 41 years		*Over 41*		*Under 41*		*Over 41*	
	£	(No.)	£	(No.)	£	(No.)	£	(No.)
Industry	1,350	(26)	1,500	(56)	2,400	(9)	3,050	(32)
University	1,250	(20)	1,400	(56)	2,300	(5)	2,400	(27)
Government	1,250	(18)	1,500	(49)	—	—	2,100	(7)
All other	1,300	(36)	1,450	(57)	—	—	2,550	(17)
All groups	1,300	(100)	1,450	(218)	2,350	(15)*	2,650	(83)

* *Includes one Government return*

Salaries of Associates

As was shown in previous surveys, there is a high correlation of salary with age, over the age range 25–40, for members of this grade. The same procedure as in 1951 has been adopted. For the occupation groups containing adequate numbers of returns, the average salary in each two-yearly age group has been plotted and a curve drawn through the points. Figure 1 shows these curves of average for some of the occupational groups ; for comparison, the industrial curve of 1951 is also given. The scatter of the returns is indicated on Figure 2 which consists of a number of curves showing the approximate limits between which more than 80% of the returns in different occupational groups lie.

Industry (331 returns)

The curve shown on Figure 1 indicates an average salary for Associates in this group of about £720 at age 26 and an annual increment of approximately £40 to a salary of rather more than £1,250 at age 40. This represents an average increase, for a given age, of about 20% over the salaries of 1951. The curve is well defined.

There are not sufficient returns to define the curve much beyond the age of 40 ; the returns from the 30 oldest members

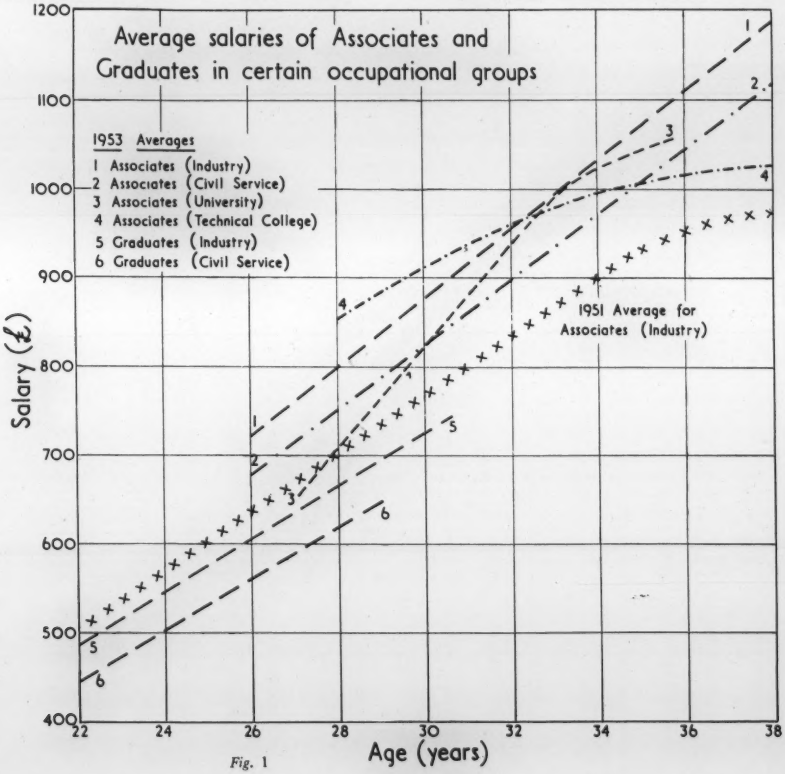

Fig. 1

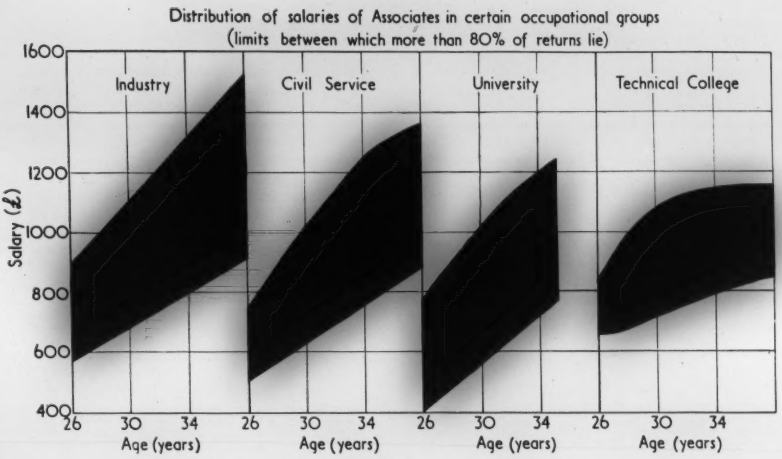

Fig. 2

of this group (44 years and over) show an average salary slightly over £1,600. Seventeen returns in this occupational group are of salaries over £2,000 per annum ; of these, one is from a man under 30 years of age ; 6 from men 31–40 and 10 from men over 41.

Universities (122 returns)

There appears to have been no significant increase since 1951 in average earnings of the young members of this group but the average in the age range from about 30 to 34 (which also contains the largest proportion of returns) has increased by an amount similar to the corresponding industrial increase. It is likely that most Associates in university posts transfer to Fellowship by about the age of 35. The few returns from Associates over that age suggest a flattening of the curve of average salary to a maximum of about £1,100.

Scientific Civil Service (183 returns)

The average salary in this group has increased over the whole age range up to 40 by almost the same amount as for industrial returns and, as in 1951, the curve lies about £50 below the industrial curve. There is evidence of a flattening of the curve above the age of 40 to a maximum much lower than that of industry. The 17 returns over the age of 43 show an average salary of just under £1,300.

Technical Colleges (102 returns)

In some respects, this group shows the most marked change since 1951, reflecting the introduction of the new Burnham (Technical) scales three months after the completion of the previous enquiry. It is clear that many of the posts on the Lecturer scale (minimum salary £900) and Senior Lecturer scale (minimum £1,000) have been filled by young men and the average salaries of the 22 returns in the age range 26–30 are above the industrial average. The curve is well defined beyond 45 with a flattening to an average of £1,100.

Research Associations (63 returns)

The averages follow closely the civil service curve.

Schools (74 returns)

The returns are mainly from older men. The distribution of salaries, including allowances, is shown in the following table.

Table 8. *Associates in Schools*

Age	*Under £700*	*£700–£799*	*£800–£899*	*£900–£999*	*£1,000 and over*	*Total*
Under 31	1	3	1	—	—	5
31–40	1	8	10	4	4	27
Over 41	—	3	19	7	13	42
	2	14	30	11	17	74

Of the returns over £1,000 only seven specifically refer to special allowances ; the remainder are presumably fixed salaries paid by independent schools. Among the remaining 57 returns, 40 include special responsibility allowances, 15 under the age of 41 (from 28 returns), average allowance £100, and 25 over the age of 41 (from 29 returns), average allowance £125.

Hospitals (33 returns)

There is again too small a return in this group to adopt the same procedure as with the other occupation groups. There is some indication, however, that in this branch of the profession a number of young men have had the opportunity of senior responsibility and that average salaries at present are somewhat higher than in other occupational groups.

Comparison with previous inquiries

The following table indicates some of the changes in the approximate average salaries of Associates of all groups as shown by the 1948, 1951 and 1953 surveys. Salaries are given to the nearest £25.

Table 9. *Average Salaries of Associates in 1948, 1951 and 1953.*

Age	1948 £	1951 £	1953 £
26	500	575	700
30	600	725	850
34	700	850	1,000

An Associate whose salary had followed the average and who was aged 28 in 1951 would have had an increase from about £650 then to £850 now, £80 as normal increments and the remainder from rising general rates. For an older man, say aged 35 in 1951, the increase would be from rather less than £900 in 1951 to £1,100 now.

Approximate median salaries for Associates of all occupational groups are :—under 30 years of age £750 ; 31–40 years £1,000 ; over 41 years £1,100.

Graduates

The grade of Graduate was instituted only in 1949 and as yet consists predominantly of men under the age of 30. Of Graduates in the Universities, most are receiving grants for full-time research and have been excluded from this analysis. The only two groups with sufficient returns for adequate interpretation are industry and the civil service and the two curves of average salaries are shown on Figure 1. These curves are well defined, corresponding with an industrial salary of about £480 at 22, increasing by £30, and a civil service salary at the same age of £440, increasing by £30. The lower parts are consistent with an extrapolation of the Associate curves and the portions above the age of 26 or 27 are probably indicative of an increasing proportion whose work is of insufficient responsibility to qualify them for transfer to Associateship.

Acknowledgment

The data have been analysed by the Deputy Secretary, Mr. N. Clarke, who has also prepared the report, on the draft of which the Honorary Secretary, Dr. B. P. Dudding gave valuable advice. The Board wishes to record its thanks to Dr. Dudding and Mr. Clarke.

APPOINTMENTS VACANT

The inclusion of particulars of a vacancy must not be taken to imply that the Institute necessarily approves of the terms offered or that might be offered. Candidates should satisfy themselves that these are satisfactory, and they may always refer to the Institute for advice.

College of Technology, Birmingham, Department of Physics and Mathematics. There is a vacancy in physics for an Assistant, Grade "B." The department is concerned with Intermediate, General and Special Degree courses for London University. Post-Graduate courses and National Certificates in Applied Physics. The successful candidate will have an opportunity of taking part in an extensive research programme in electronics and applied physics. Applicants should have good qualifications in Physics. Teaching and/or industrial experience will be an advantage.

Salary will be in accordance with the Burnham (Further Education) Scale for Assistants Grade "B," (Men) £490 x £25 —£765, (Women) £437 x £20 (final increment £15)—£612, with additional graduate and training allowances where applicable. In fixing the commencing salary, allowance will be made for teaching, and approved industrial experience.

The appointment will date from January 1, 1954, or as soon as possible thereafter.

Further particulars and form of application may be obtained from the **Registrar, College of Technology, Suffolk Street, Birmingham, 1,** on receipt of stamped addressed foolscap envelope. Completed forms should be returned to him not later than two weeks after the insertion of the advertisement. C. McCaw, Clerk to the Governing Body.

National Coal Board invite applications for superannuable appointments as **Scientists** at their **Central Research Establishment II, Isleworth, Middlesex,** to work in a group studying methods of establishing suitable instrumentation for use in mines, and to design and prove instruments required for use in all aspects of mining and research into mining techniques.

Candidates should have a first or second class honours degree or equivalent qualification in Physics or Engineering. Some post graduate experience in any of the following fields is essential :—light engineering, pneumatic and/or hydraulic mechanism design, design of light electrical, electronic or optical mechanisms.

Appointments will be in the grade of either Scientist II (£645 x £30 – £1,095 male, and £545 x £25 – £795 x £30 – £945 female) or Scientist III (£445 x £25 – £845 male, and £420 x £20 – £720 female), according to qualifications and experience. London Location Allowance of £32 10s. 0d. rising to £78 per annum at the maximum of the scales, is payable in addition.

Write giving full particulars (in chronological order) of age, education, qualifications and experience (with dates) to **National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1,** marking envelope TT/709. Original testimonials should not be forwarded. Closing date 28th December, 1953.

Development Engineer required by scientific instrument and laboratory apparatus manufacturers. The post offers scope to a qualified mechanical engineer with initiative, inventiveness and the ability to work in a development team. Applicants should have drawing office experience, sound knowledge of workshop practice, including sheet metal work and instrument making. Salary according to experience and qualifications, pension scheme, 5-day week. Applications in writing stating full details to **Technical Adviser, A. Gallenkamp & Co. Ltd., 17-29 Sun Street, London, E.C.2.**

Honours physics graduate required for work in **research laboratory** in connection with factory problems. Experience in electronics particularly photo-electric devices a distinct advantage. Commencing salary £600–£700 p.a. according to age, experience and qualifications. Non-contributory pension, and insurance plan. Scope for advancement. Apply in writing to **Personnel Department, Kodak Limited, Wealdstone, Harrow, Middlesex.**

Physicists and **Engineers** required by **Ministry of Supply, R.A.E., Farnborough, Hants,** Instrument and Photographic Department. Post 1 (Ref. A.247/53A/) Scientific Officer for research and development in connection with gyroscopic and allied instruments. Some related experience and practical knowledge of electronics desirable. Considerable scope for inventive ability. 1st or 2nd class honours degree or equivalent in Physics or Engineering required. Salary within range £417—£781. F.S.S.U. benefits may be available. Posts 2 and 3 (Ref. A.248/53/A) Experimental Officer (E.O.) or Assistant E.O. to assist in above duties. Practical experience of development in light mechanical or electro-mechanical field desirable. Post 4 (Ref. A.249/53/A) E.O. for research and development mainly in photographic optics. Experience in the manufacture and testing of photographic lenses and optical equipment desirable. E.O. Class minimum qualification—Higher School Cert. (Science) or equivalent but H.N.C. or degree in Physics or Engineering may be an advantage. Salary within ranges : E.O. (min. age 26), £649—£799 or Asst. E.O. £264 (age 18)—£576. All appointments unestablished. Rates for women somewhat lower. Application forms from M.L.N.S., Technical and Scientific Register (K), 26 King St., London, S.W.1, quoting appropriate reference.

Physicist with a few years experience in infra-red work is required for interesting research and development work by the **Research Department of Cambridge Instrument Company, Limited, Cambridge.** Applications should give full details of qualifications and experience. Commensurate salary with superannuation benefits will be paid.

The Research Laboratories of **The General Electric Co. Ltd., North Wembley, Middx.,** have vacancies for **physics** or **electrical engineering graduates,** preferably with an Honours degree, to work in the field of electronic circuitry of the pulse communications and computor type. Candidates must have completed National Service. Apply in writing to Staff Manager (Ref. RLO/9), giving full particulars of age, qualifications and experience.

Kodak Limited, Wealdstone, Harrow, Middlesex, have vacancies for male **technicians** up to 30 years of age who will be trained to work in Production Departments. Salary will be according to age, qualifications and experience in the range of £500–£650 (starting). Non-contributory pension, and insurance plan. Men with a University degree in Science should apply by letter to the **Personnel Department.**

Scottish Woollen Technical College. Applications are invited from honours graduates in **Physics** or **Engineering** for the post of **Research Assistant** to the Principal of the College, to carry on research into the physical principles of the woollen textile processes. Previous textile experience is not essential. Salary scale £600–£1,015. A house is available.

Applications should be addressed to the **Principal, Scottish Woollen Technical College, Galashiels, Selkirkshire,** from whom further particulars may be obtained.

Ilford Limited require a **graduate,** in physics or with physics as a subject, for supervision of a sensitometric unit and compilation and assessment of sensitometric records, at Brentwood, Essex. Applicants should be experienced in sensitometry or in scientific applications of photography. Age 25-40 years preferred. Salary according to age and experience. Apply in writing to **Research Director, Ilford Limited, Ilford, Essex.**

The Fulmer Research Institute, Stoke Poges, Bucks., has two vacancies for **metallurgists** or **physicists** for equilibrium studies of reactive metals and for general metallurgical and X-Ray work. Candidates should have good honours degree in physics or metallurgy. Previous experience not essential, salary according to qualifications and experience in range £600–£850.

Development engineer required for work on design of new scientific instruments. The work is of a varied electrical nature, and ranges from low-frequency electronic equipment to apparatus involving galvanometers, bridges and potentiometers. The post will be of interest to applicants wishing to take part in all stages of design through to the production stage A physicist (or electrical engineer with good physical knowledge) of several years' experience is required. A salary of up to £900 p.a. will be paid according to qualifications and experience. Please send full details to **W. G. Pye & Co. Ltd.,** " Granta " Works, Newmarket Road, Cambridge.

Research assistant under 30 required for work on electron microscopy and diffraction at a university laboratory, Cambridge. Honours graduate in physics preferred. Previous experience in this field not essential, but mechanical ability and knowledge of high vacuum technique an advantage. Applications with full personal particulars, qualifications and experience by January 8, 1954. Box A.V.51.

Photoconductivity. A **physicist** is required by Cathodeon Ltd., the vacuum tube division of the Pye Group of Companies to lead a small team engaged in investigating the properties and applications of photoconductive materials. The salary will be good and in accordance with the successful applicant's qualifications and experience. Apply in confidence giving full details to the **Director, Cathodeon Ltd., Church St., Cambridge.**

Physicist with a good honours or higher degree required by **Dunlop Research Centre** to carry out fundamental research on textiles. Previous textile experience desirable but not essential. Applications in writing quoting reference J.M.22 and giving details of age, qualifications and experience to Personnel Manager, **Dunlop Rubber Co. Ltd., Fort Dunlop, Birmingham 24.**

Ferranti Limited, Manchester, have staff vacancies in connection with transitor development at their new laboratories at Wythenshawe, South Manchester.

(I) **Engineers** and **Physicists** are required for fundamental work on semiconductors and transistors and for work on transitor manufacturing techniques. Qualifications required : 1st or 2nd Class Hons. degree in Physics, Electrical Engineering or Metallurgy ; experience in a relevant field is required for the more senior posts. Salary according to qualifications and experience in the range of £500–£1,500 per annum. Please quote ref. P.D.H. (I)

(II) **Technical Assistants** for experimental work in the fields listed above. Please quote ref. P.D.H. (II). Qualifications required : a degree or Higher National Certificate in Physics, Electrical Engineering or Metallurgy or equivalent qualifications. Salary according to age and experience in the range £400–£600.

The Company has a Staff Pension Scheme. Application forms from Mr. R. J. Hebbert, Staff Manager, Ferranti Ltd., Hollinwood, Lancs.

Research Scientist required for research on domestic heating. Applicant should have B.Sc., preferably in Physics. Age 26–34. Starting salary £600—£800. Previous research experience in fuel technology and/or instruments an advantage. Pension scheme. Apply in writing to the Assistant Secretary, Ref. A.37, **British Coal Utilisation Research Association,** Randalls Road, **Leatherhead,** Surrey.

Manchester Municipal College of Technology (Faculty of Technology in the University of Manchester). Appointment of an Assistant Lecturer in Chemical Engineering. The Governing Body invites applications for an **Assistant Lectureship in Chemical Engineering** in the College of Technology with the title and status of Assistant Lecturer in the University of Manchester.

Candidates should be graduates in Chemical Engineering or graduates in Chemistry with post-graduate training and/or experience in Chemical Engineering, and will be expected to undertake research in Chemical Engineering.

Salary : £500 per annum, rising by annual increments of £25 to £600 per annum. Commencing salary according to qualifications.

Conditions of appointment and form of application may be obtained from **The Registrar, College of Technology, Manchester 1.** The last day for the receipt of applications is 31st December, 1953.

Canvassing, either directly or indirectly, will disqualify a candidate for appointment. B. V. Bowden, Principal of the College.

Monmouthshire Education Committee. The Technical College of Monmouthshire, Crumlin. **A Laboratory Technician** to take up duties on the 1st January, 1954, or as soon as possible after that date, is required at the above College.

Candidates must have had experience as a Laboratory Assistant or Steward and should have a good practical knowledge of one or more of the following Crafts, viz. :— Scientific Glass-Blowing, Carpentry, Photographic Processing Instrument or Apparatus repair, or Preparation of Metallurgical Specimens.

Candidates should hold an appropriate Ordinary National Certificate. Salary £400 x £20 x £15 x £15 to £450 per annum.

Forms of application obtainable from the undersigned to be returned not later than 24th December, 1953. **C. E. Gittins, Director of Education, County Hall, Newport, Monmouthshire.**

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